Spatially Resolved XAS Measurements of Particulates in Lung Tissue

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INTRODUCTION

Lung tissue samples obtained from Russian nuclear industry workers have been observed to have numerous particles imbedded in them. The particles are typically in the micron to ten's of micron size range and many contain heavy metals. X-ray fluorescence microprobe (XFM) and spatially resolved XAFS studies were carried out on beamline 10.3.1 and 10.3.2 respectively, to determine the size, composition, and chemical state of these particles. The overall goal is to try to correlate the properties of these particles and their chemical nature to the health effects on these industrial workers.

EXPERIMENT

Lung tissue samples were obtained from autopsies of Russian nuclear industry workers who had died of cancer. The workers were typically male, had been exposed to metallurgical refining for many years, and were, generally, heavy smokers. Lung tissue samples were mounted on a thin plastic film and dried in air. The samples were typically 5 mm by 10 mm and 2-3 mm thick. Preliminary XFM measurements were taken on BL 10.3.1 at the ALS with the collaboration of Scott McHugo, Al Thompson, and Keith Jackson of the CXRO at LBNL. Measurements reported here were taken on the new microfocus line (BL 10.3.2) at the ALS built by MacDowell et al. [1]. BL 10.3.2 uses a 4 crystal monochromator followed by KB focusing mirrors[1]. It has been shown to achieve a beam size of 0.8 by 0.8 microns with flux densities of 10^7photons/ sec in the energy range of 4 - 11 keV.

XFM measurements were taken over selected areas in the sample including both diseased and healthy tissue. An area of about 100μ by 100μ was scanned in 5 μ steps and a Si(Li) detector was used to identify the atomic species present. An excitation energy of 12 keV was used so that elements up to As could be identified from their K_a lines.

An area was chosen which contained small particles containing Cu and Fe. We used this area for spatially resolved XAFS measurements. The focused beam was used and XAS spectra were

collected at the Fe and Cu K edges. Points of interest were first located by rastering the sample in 5 μ steps over a region identified as being of interest from results taken at 10.3.1.

Once the particles of interest were found, five scans were done at each edge, over a range of -50 to +400 eV. Each scan took about 40 minutes. Improvements in the software (permitting regions to have different stepping increments) now enable scans with the same degree of extractable speciation information in them as those previously taken to be measured in approximately 30% of the time it took previously.

RESULTS AND CONCLUSIONS

Numerous micron sized particles have been seen in both healthy and diseased lung tissue. Several different elements were seen overall, some in isolated particles and others associated in the same particle or region. Heavier elements may also be present which could not be seen because of the excitation energy (12 keV) used here. An area was located which contained Fe and Cu. The maps for this area are shown in Figure1. The μ-XAFS spectra, using a micron sized beam, were obtained in this area for both edges. The μ-XAFS spectra were consistent with oxidized states for each element of 3+ for Fe and 2+ for Cu, respectively. These studies demonstrate the feasibility of characterizing the chemical state of micron sized particles in human tissues.

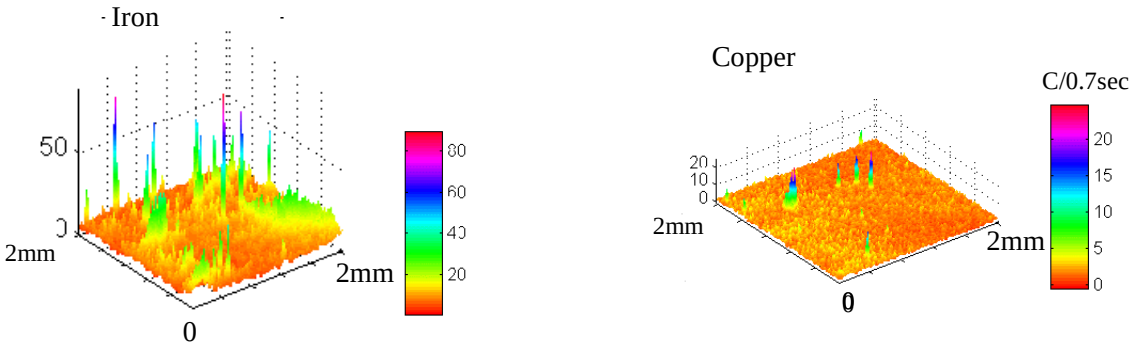

Figure 1. : Fluorescence maps of Copper Kα and Iron Kα in the region of interest

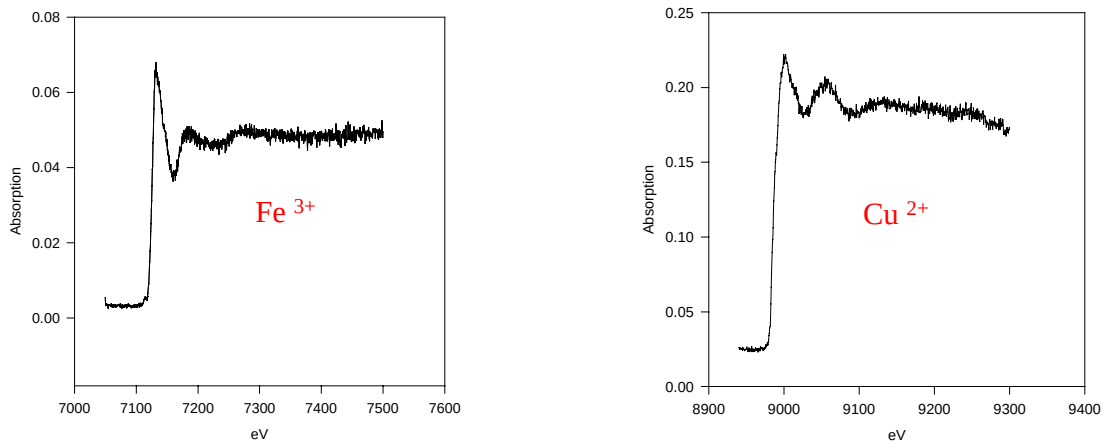

Figure 2. Oxidation states of Cu and Fe were determined by observing the edge position in relation to standard compounds.

These results are preliminary but are potentially very significant because they may help in providing key information about the role of small metal particles in pulmonary disease. To be more definitive will require an extensive set of measurements with many samples whose medical history is well understood. This, in turn, will require a much higher level of manpower and support than is currently available.

These results were presented as part of a poster at the recent XAFS X Conference that also included x-ray XFM results taken at 10.3.1. We believe that we have now demonstrated the potential for this work and are in the process of putting a team together to prepare a proposal to use both XFM and spectromicroscopy to study heavy elements in human tissue and relate them to disease. We are trying to identify someone in the US who can work with us on the health effects and coordinate with our colleagues in Russia where there is an extensive team there who can obtain samples and medical histories. Presently we are manpower limited to do much more. We would like to develop a significant program in this area to look at the correlation to health effects of other small particles, both airborne and *in situ*, such as calcifications, where it is believed that particle size, morphology, and correlated distributions of calcifications may play a role in some types of breast cancer. We believe that once these results start to be made available to the wider community it will spur additional medical imaging applications using synchrotron radiation.

REFERENCES

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